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CPV standardization: An overview

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ABSTRACT

Concentrator Photovoltaic (CPV) is showing a growing trend in the energy market as a consequence of the big investment made by the Photovoltaic industry; but this industrial and commercial growth will be successfully possible with the simultaneous creation of standardization norms that certify the reliability and durability of the CPV systems manufactured. Additionally, the revision of the present CPV standard released is a necessary task as some organisms and laboratories are encountering with some technical problems.

Contents

1. Introduction

Concentrator Photovoltaic (CPV) systems have been present throughout the development of PV technology, but despite the time passed by, the complexity of the technology used and the size of the CPV industry have delayed the evolution and high-scale establishment of these systems. The total world power installed up to 2007 proves that statement, as it only reached some mega-watts [1]. Nevertheless, as a consequence of the accumulated $1 billion investment over the past few years, the industrial sector has forecast a total installed power of 2 GW by 2010 [2].

This optimistic industrial and commercial growth is only possible if its deployment is combined with the creation of norms that regulate not only the design and manufacturing stages, but the energy and power rating too, apart from other requirements discussed for traditional flat-PV.

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The purpose of this paper is to review the state-of-the-art of the CPV standardization and its highs and lows, concerning to the present norm and possible improvements.

2. Standardization and testing norms

The creation of standards that regulate the manufacturing process and quality of a particular technology is essential when a product needs to achieve a significant and widespread industrial and commercial growth.

These standardization and testing norms guarantee the operational behavior, safety and profitability in any system. The reliability and durability of a technology define these characteristics; as the primer measures the mean time between failures (MTBF) or the time needed to repair a certain failure, the later refers to the lifetime of the system, which it is a point in time from which it is not profitable to maintain the operation of the system.

If CPV technology wants to compete against flat-plane PV or traditional energy sources, the levels of reliability and durability have to be similar in order to guarantee a good performance,

because the accumulation of failures in the course of its lifetime (poor durability) can reject the establishment of the whole CPV industry due to its lack of reliability.

To guarantee these levels of reliability and durability, it is necessary to certificate the CPV modules and/or assemblies through the application of Specimen and Serial Tests to assure that they accomplish the standard specifications.

It is necessary to differentiate between standardization and certification. While standardization is a set of rules that unify the process, procedures and parameters of the CPV systems, certification is the action carried out to make sure that the CPV product observes the requirements of a specific standardization norm [3]. Institutions like the International Electrotechnical Commission (IEC), in the case of this CPV standard, are the organisms in charge to transform this set of rules based on the experience and technical developments into norms that regulate this standardization. At this point, independent organisms must carry out the procedures indicated in the norm to certificate that the CPV modules/assemblies gather the requirements of the norm.

In the case of CPV systems, standardization is becoming a crucial aspect if this industry wants to achieve a worldwide and competitive energy market. Most common causes of failure detected in CPV systems such as condensation inside the modules, power degradation due to the thermal cycling, heat evacuation, electrical isolation or loss of alignment in the performance of trackers among others, could be removed or drastically reduced if the suitable standardization norms were created; increasing therefore the warranties that investors need to bet for a large-scale CPV penetration in the energy system.

3. CPV qualification standard: IEC 62108

The IEC 62108 norm is the first standard developed exclusively for CPV technology and its object is to determine the electrical, mechanical, and thermal characteristics of the CPV modules and assemblies and to show within reasonable constraints of cost and time, that CPV modules and assemblies are capable of withstanding prolonged exposure in open air climates [4].

This standard is a compendium of accelerated aging tests that identify long-term reliability problems in the CPV modules and assemblies, reducing the risk of failure of the system; in other words, the goal of this qualification standard is to guarantee the durability and reliability of the CPV systems [5].

The tests applied in the Qualification Test Sequence can be gathered in five different groups according to the parameters that measure: Diagnostic Tests, Electrical Tests, Climatic Tests, Mechanical Tests and Irradiance Tests. All the tests include a pass criterion that the modules and assemblies must fulfill in order to get the qualification and type approval.

Historically, the IEC 62108 standard is a mixture between two previously released standards: IEEE 1513 and IEC 61215. Related with the first one, IEC 62108 is an evolution of the IEEE 1513 qualification standard: "IEEE Recommended Practice for Qualification of Concentrator Photovoltaic (PV) Receiver Sections and Modules", published in 2001; but the requirements for the tests in the present standard are stricter although the procedures of the tests are less complicated and better detailed [6].

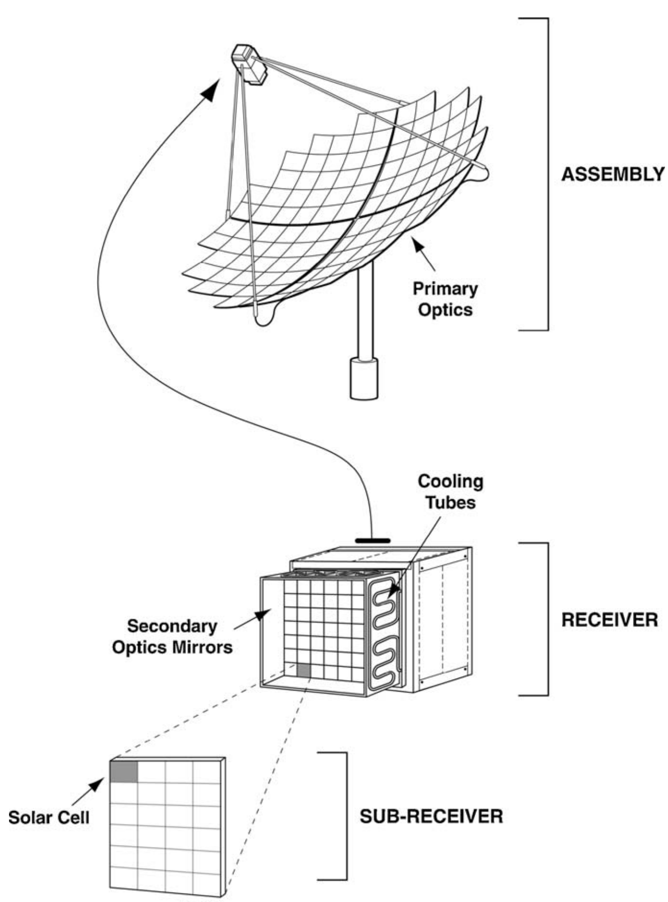

Fig. 1. Point-Focus Dish CPV. (*Source*: IEC 62108).

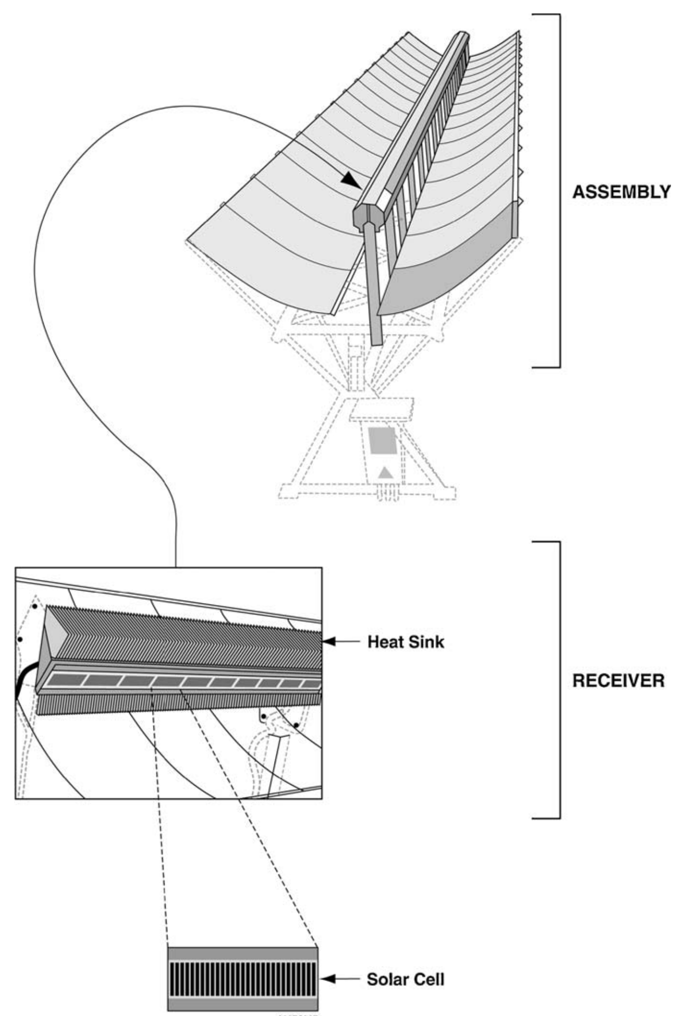

Fig. 2. Linear-Focus Trough CPV. (*Source*: IEC 62108).

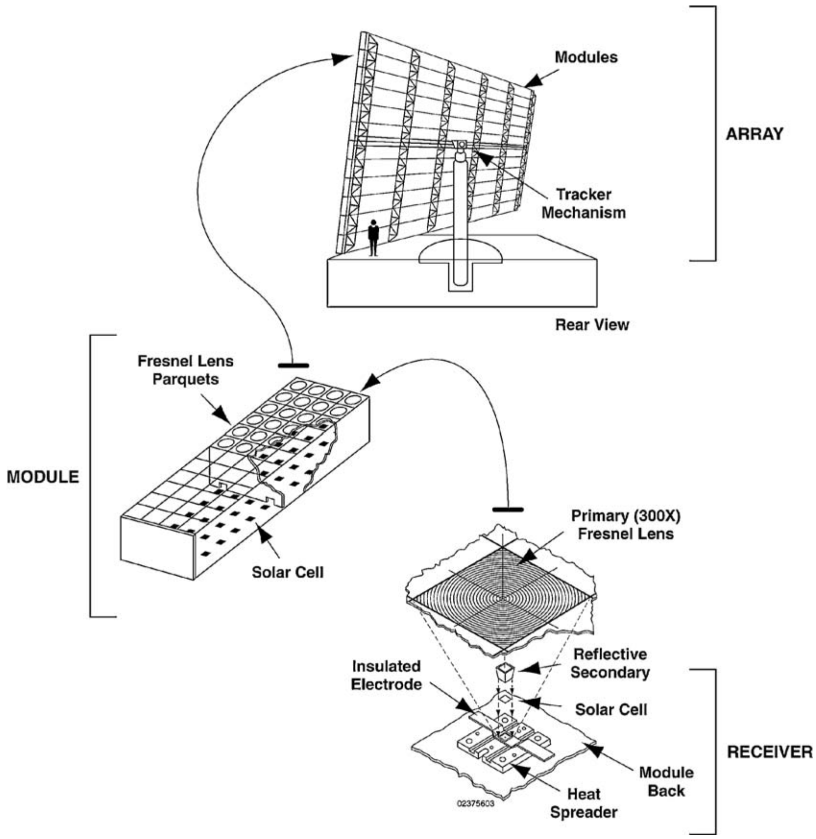

Fig. 3. Point-Focus Fresnel Lens CPV. (*Source*: IEC 62108).

The main differences between IEEE 1513 and IEC 62108 lie in the number and order of the tests applied to the modules and receivers in the qualification tests program and the sort of CPV systems included in the norm; while IEC 62108 standard covers five different technologies (Figs. 1–5), IEEE 1513 only takes under consideration three systems (Fig. 6).

Regarding to the second standard mentioned, it can be said that the tests compiled in the CPV standard are partially based on the ones specified in the IEC 61215, which it is a flat-plane PV norm; but there are some differences between the tests described in both standards; for example, the outdoor exposure test, the UV conditioning test, the damp heat and humidity freeze tests, the maximum cell temperature and the thermal cycling tests have been modified significantly to be adapted to the particularities of the CPV technology.

The distribution, order and the inclusion of new tests such as dark IV measurement, water-spray test, off-beam damage and ground path continuity, are also a notorious difference when the Test Sequence is compared in both standards as it can be observed in Fig. 7 [7].

This adaptation emphasizes the differences in the characteristics and behavior of CPV and traditional PV technologies.

4. Highs and lows of the CPV standardization

4.1. Lack of standardization norms

It is outstanding the lack of CPV standardization norms, as only one standard has released up to now, which means that CPV technology is growing up using PV standards and sometimes with the total absence of norms when referred to some specific parts; but this reason is partially justifiable by the recent development, in economical terms, of the technology.

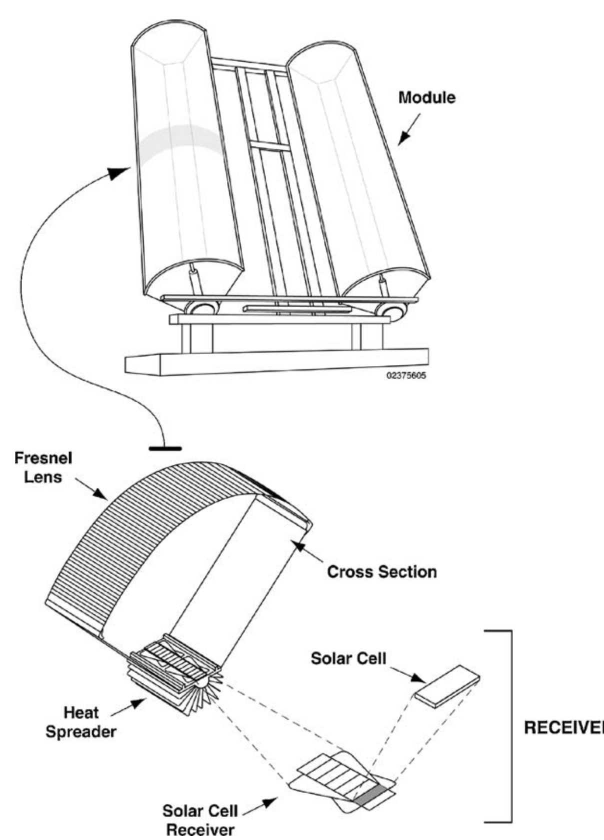

Fig. 4. Linear-Focus Fresnel Lens CPV. (*Source*: IEC 62108).

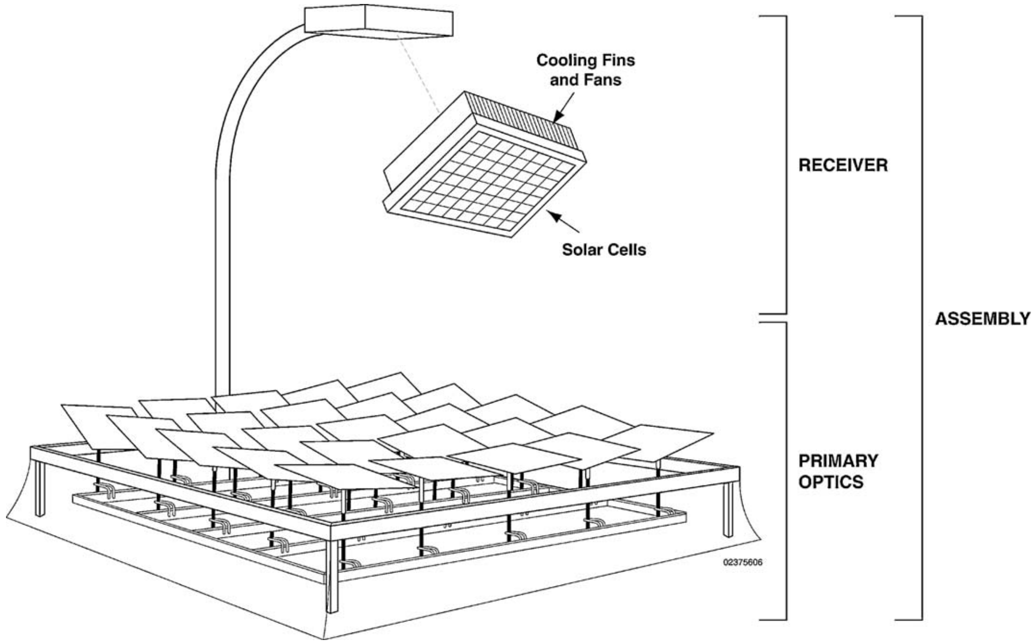

Fig. 5. Heliostat CPV. (*Source*: IEC 62108).

The main standard missing in CPV is the one related to the performance rating, as there is no official procedure for rating its electrical performance, together with a disagreement in defining its Standard Test Conditions [8,9].

Another outstanding phenomenon is the exponential growth of trackers used for traditional and CPV systems with no standardization criteria [10]. No certificate organism is checking the trackers developed, because no standardization

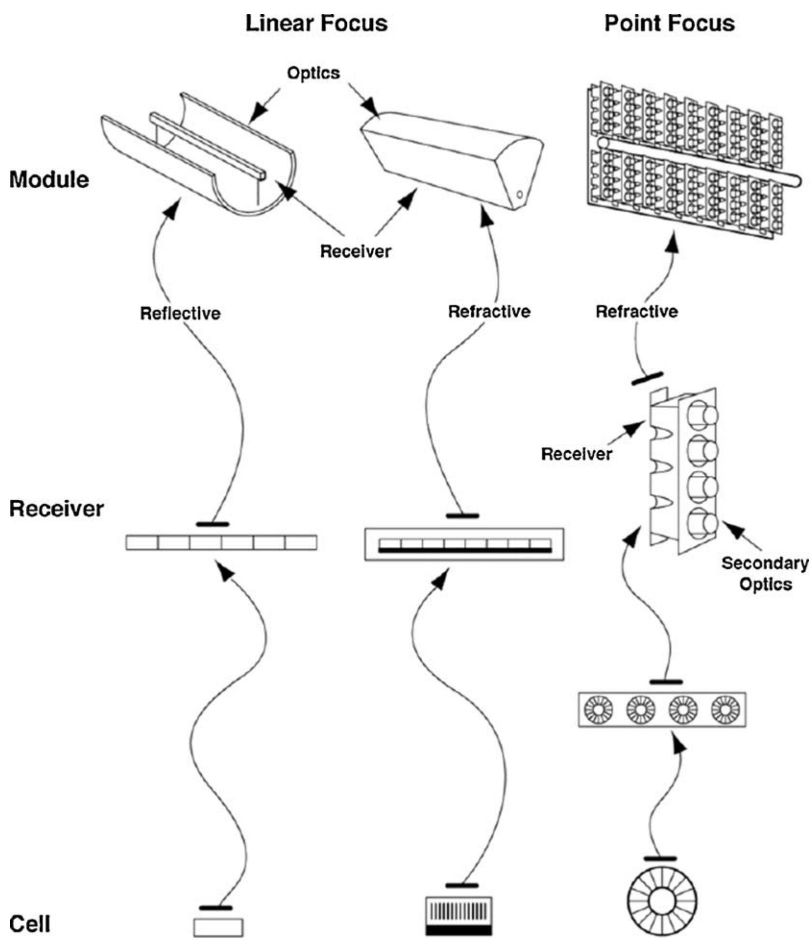

Fig. 6. IEEE 1513 standard CPV systems (*Source*: IEEE 1513).

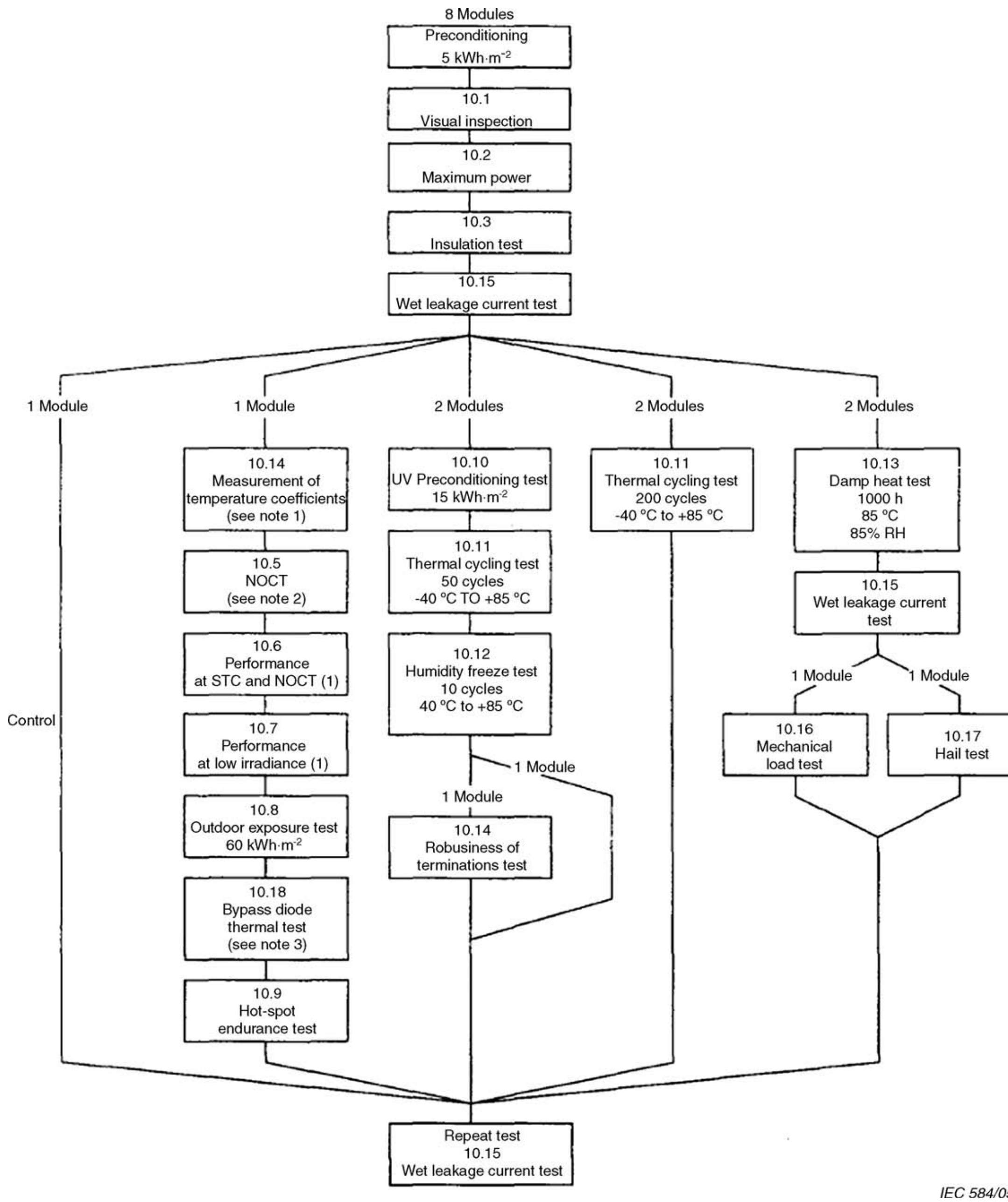

Fig. 7. Qualification test sequence in IEC 61215 standard. (*Source*: IEC 61215).

norm has been created. This particularity can produce an important and significant problem in the trackers industry as no control process is applying to the development of the trackers.

Resuming the overview of lack of standardization norms, the more urgent regulations that CPV must accomplish are:

- Power and Energy Rating.
- Tracker Standard.
- Safety Standard.
- Measurement Standard.

4.2. Possible improvements in the IEC 62108

Focusing on the standard recently released, IEC 62108, there are several points that should be taken under consideration and maybe included in the revision of the standard.

This standard gathers under the same norm five different CPV technologies to apply the tests. Firstly, new CPV systems are constantly emerging, so as it is impossible to revise very frequently the norm, it would be a good idea to write a norm or an annex in the present one that defines and delimits which systems can be gathered under the denomination of Concentrator PV. Additionally, it is not viable to consider under the same standard such a wide variety of CPV systems as IEC 62108 does, because the systems have different performance behavior among them and there are tests that could be extremely restrictive with some systems that do not require the pass criteria levels defined. As the IEC 61215 standard for flat-PV modules differentiates in its scope the application of the norm between silicon modules and thin-film ones by defining a different norm, with CPV technologies should be similar, moreover when under the same technologies described in the CPV standard, manufacturers use different solar cell types, increasing even more the variety of possible CPV systems.

Some organisms and laboratories are encountering with technical problems when applying some of the tests described in the norm. For example, in relation with the dark IV test, shunt effects could be induced and negative resistance behavior was detected under a certain current threshold [11]; while certification organisms are having difficulties in the measurements of electrical performance because there is no definition on the measurement methods for the CPV modules power. They are also finding some critical circumstances for indoor testing such as the climatic chamber conditions and the climatic test duration, additionally with the versatility that their equipments must have in order to test the variety of CPV systems gather under the same standard [12].

Another critical point detected comes up with some degree of freedom in the application of certain tests. For instance, the possibility to test representative samples of the modules or assemblies if the full-size model is too large to fit into the testing equipment. It can be very expensive to develop a representative sample that achieves the same electrical, mechanical and thermal characteristics, and moreover, technically it is almost impossible to achieve the same behavior and operation characteristics of the original model. Another point not specified clearly come up when the standard allows that if some tests of the standard are not applicable to a specific design, it can be discussed the development of a comparable test program.

Even though the hitches detected in the IEC 62108 standard, the big efforts that many laboratories and research centers are doing, will lead the revision of this standard to the right direction.

5. Conclusions

CPV systems are still in a pre-commercialization stage, but a wide industrial deployment is not only dependent on the improvement of its technology, but the creation of standards that guarantee its operational behavior.

Nowadays, CPV industry is developing drafts for safety and performance of the systems, power and energy ratings and BOS drafts such as trackers. International organisms are involved in this task, such as the IEC, The Institute of Electrical and Electronics Engineers (IEEE) and The American Society for Testing Materials (ASTM), accompanied with the essential field experience of institutions like ISFOC (Instituto de Sistemas Fotovoltaicos de Concentración).

The possible improvements in the present standard and the working teams for the development of the new ones, assure that CPV industry is running towards the commercialization stage with a solid foundation.

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